

**Event Study: The Influence Of COVID-19 Research and Development  
News on Pharmaceutical and Biotech Companies**

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### **Abstract**

This event study estimates the influence of COVID-19 related research and development news on pharmaceutical and biotech companies and its impact on the stock market. Results show that companies can grow 4% to 63.92% from their development progress, except for Johnson & Johnson's -2.96% loss on January 29<sup>th</sup>, 2021. Dynamics between vaccine and treatment drug developers were collaborative initially and more competitive later. The market prefers certain firms such as Moderna, CureVac, and Gilead, who are less likely to be defeated by others' success and more likely to disrupt others with their progress. Private and public benefits from vaccine and drug developments mostly align, except when Novavax's and Johnson & Johnson's positive announcements collided. Lastly, positive market sentiment seems to influence small-cap and mid-cap firms more than large-caps, while negative events have less impact on them.

## I. Introduction

This event study estimates the influence of COVID-19 related research and development news on pharmaceutical and biotech companies and its impact on the stock market. During COVID-19, the healthcare sector is attracting significant investments from governments and investors. The pandemic outbreak severely damaged the U.S economy and stock market during March 2020, which exacerbated domestic and external political conflicts. Therefore, the U.S government has invested billions in vaccine companies, aiming to accelerate trials. Private investors are also paying close attention to the pharmaceutical and biotech sectors. Even though some may argue that a COVID-19 vaccine is far less lucrative than cancer drugs to pharmaceutical giants like Johnson & Johnson, it can still be an attractive business due to revenues from large government contracts. For small biotech companies, COVID-19 vaccine development can be even more rewarding. Novavax only generated \$18.66 million in revenue during 2019, while Johnson & Johnson gained \$82.1 billion for the same calendar year<sup>2</sup>. If Novavax can successfully distribute an effective COVID-19 vaccine, it will bring colossal capital gain for its early investors.

However, the vaccine race can be risky and competitive. Accidents such as the severe adverse reactions among trial participants have already happened, which could hinder research progress and decrease company stock price by more than 10%<sup>3</sup>. Meanwhile, due to vaccine trials' competitive nature, one company's progress can bring considerable losses to its competitors. Nevertheless, some also argue that the market already anticipates such risk. Hiatus in research can also show that companies have taken necessary safety precautions, which increases the public trust towards vaccines<sup>4</sup>. Some media also pointed out that the COVID-19 vaccine trials are highly

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<sup>2</sup> Numbers retrieved from published financial reports of each company mentioned.

<sup>3</sup> Observed from FactSet stock price charts and AI price-news analysis function

<sup>4</sup> Argued by the Wall Street Journal and several media

cooperative compared to other vaccines<sup>5</sup>. Diestre and Nandini (2012) discovered that new biotech firms often select pharmaceutical firms as research allies. Thus, it is debatable whether the vaccine race is truly a zero-sum game. Therefore, it is crucial to measure and quantify the influence of trial news on pharmaceutical and biotech stocks.

This research focuses on four events. Event 1 is the official confirmation that the former President Trump used Regeneron's antibody cocktail for COVID-19 treatment, at 4:11 pm EST<sup>6</sup>, October 2<sup>nd</sup>, 2020. By the time of announcement, there were no approved treatments for COVID-19. This news shifted Regeneron's stock price from 564.80 dollar per share on October 2<sup>nd</sup> to 605.08 on October 5<sup>th</sup>, with a 7.13% increase.

Event 2 is Pfizer announcing its vaccine to be 90% effective at 06:45 am, November 9<sup>th</sup>, 2020. It disclosed that its study enrolled 43,538 participants, with 42% being racially diverse, and no serious safety concerns have emerged. Pfizer is the first major pharmaceutical company to achieve such high efficacy, which exceeds the 50% threshold that the US Food and Drug Administration (FDA) requires for a coronavirus vaccine's emergency use approval. This news is a milestone for COVID-19 vaccine development.

Event 3 is Moderna's announcement at 6:56 am, November 16<sup>th</sup>, 2020 that its COVID-19 vaccine mRNA-1273 has met statistical criteria with an efficacy of 94.5%, higher than expected by experts. Its phase-3 study, which enrolled more than 30,000 participants in the U.S, also displayed no safety concerns. This event is also profound since Moderna's vaccine outperformed Pfizer's in terms of efficacy, storage conditions, and shelf life.

Event 4 happened at 8:03 am EST, January 29<sup>th</sup>, 2021. Johnson & Johnson claimed that its vaccine candidate is 72% effective in the U.S and 66% effective overall at preventing moderate to

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<sup>5</sup> Argued by the Wall Street Journal and several media

<sup>6</sup> All time mentioned in this research are EST time.

severe COVID-19 syndromes. Meanwhile, it is 85% effective overall in preventing severe disease. Novavax also announced at 4:05 pm, January 28<sup>th</sup>, 2020 that its vaccine is 89.3% effective. Both events influenced the market at 9:30 am, January 29<sup>th</sup>, 2021, due to trading hour constraints.

This research uses the event study methodology to estimate the influence of COVID-19 related research and development news on pharmaceutical and biotech companies, and its impact on the stock market as a whole. It also discusses whether private gains from research and development align with social benefits. The main results are that companies generally profited from their own development progress, except for Johnson & Johnson's -2.96% loss on January 29<sup>th</sup>, 2021. Positive cumulative abnormal returns can be as high as 63.92% in Novavax's case. Dynamics between vaccine and treatment drug developers were collaborative during the first two events, when one company's progress was mostly good news for all firms. Later the market seems to prefer certain firms such as Moderna, CureVac, and Gilead, who are less likely to be influenced by others' success and more likely to disrupt others with their progress. Lastly, 75% of the events had a positive impact on the stock market, which indicates private and public benefits from vaccine and drug developments align most of the time, except when Novavax's and Johnson & Johnson's positive announcements collided.

## **II. Literature Review: Reaction Patterns of Healthcare Stocks and Proof of Shock**

A large amount of literature discussed the event study methodology and the use of intraday data. Armitage (1995) discussed widely used methods of estimating abnormal returns, including but not limited to the market model, index model, average return model, and Fama-MacBeth model. He claimed that the market model is the most commonly used and has no better alternative. Marshall, Nguyen, and Visaltanachoti (2019) discussed the benefits of using intraday data for event studies

such as stronger confidence in robustness. Aktas (2008) further suggested that when using intraday data to measure abnormal stock returns, simple procedures like mean adjusted returns do not perform worse than more sophisticated approaches. Meanwhile, Marshall, Nguyen, and Visaltanachoti (2019) suggested that correcting beta estimates via complicated models often have trivial effect on improving estimation accuracy.

Many works studied the pharmaceutical and biotech industry's innovation process, industry development, market power, profits and social impact. Lakdawalla (2018) reviewed extensive economics literature on the pharmaceutical industry and discovered that cost of pharmaceutical research and development is rising, but it is unclear whether there is more medical innovation. Spitz, Janet, and Wickham (2012) revealed that pharmaceuticals have enjoyed profits of 3 to 37 times higher than all-industry average from year 1988 to 2009, while the U.S life expectancy has not grown significantly. They suggested that many companies are abusing their market power to maximize profits, urging government control for drug pricing.

Pérez-Rodríguez and Valcarcel (2012) studied the price change of pharmaceutical stocks after product innovation and R&D news. They found that 40% of large abnormal market-adjusted daily returns are not linked with any plausible cause. Furthermore, for the remaining 40%, only 6% are related to FDA approvals. They also discovered that only 0.58% of FDA approvals of new drugs lead to significant abnormal returns. Lastly, they uncovered that the influence of negative news is more extensive than positive ones.

De Schrijver (2013) used an event study to analyze the stock return reaction of NASDAQ and NYSE listed healthcare stocks towards FDA and EMEA announcements. He used both the market model and the Fama-French model and discovered significant negative abnormal returns after negative FDA news. Like Pérez-Rodríguez and Valcarcel (2012), he found that company

stocks react more to negative news. However, he did not find significant cumulative abnormal returns after the announcement dates of both positive and negative news he selected. Nevertheless, he showed that the Fama-French model outperforms the market model.

Except for the pharmaceutical and biotech industry, there are large amount of literature using event studies to investigate the effects of important events and news in other areas. Brown and Cliff (2004) investigated market aggregate investor sentiment and its relation to near-term market return, and their results opposed the conventional viewpoint that sentiment primarily affects individual investors and small stocks. Li and Yang (2017) analyzed the cross-section and time-series effects of investor sentiment on stock prices. Contrary to Brown and Cliff (2004), they discovered that individual stock sentiment influences small-cap firms more than large-caps, especially during stock market downturn.

Naubert and Tesar (2018) used an event study approach to estimate the burden of Systemically Important Financial Institution (SIFI) designation. They found significant abnormal returns on the date of ruling and estimated SIFI designation cost using company financials. Although their focus is not on pharmaceutical companies, their study shows that one can prove chosen announcements to be a shock by using Google search trends and that it is possible to assign a dollar value to news items.

This research differs from previous literature for its focus on COVID-19 related research and development news. It also primarily concerns middle to large-cap (valuation is at least two billion dollars) companies who are in leading positions in the vaccine and drug development race. Meanwhile, for the selection of events, I found that selected companies' stock price movements are more correlated with development progress than negative incidents such as severe adverse reactions. Therefore, the research mainly studies positive announcements.

### III. Methodology

This research adopts the event study approach, and the following equations are from Armitage (1995) and Naubert and Tesar (2018). The primary model is the market model, which considers the focal firm's risk by multiplying the market return with the firm individual  $\beta$  factor.

$$E(R_{i,t}) = \alpha_i + \beta_i * R_{M,t}$$

where  $R_{i,t}$  is the minute return of the stock of observation  $i$  on day  $t$ ,  $R_{M,t}$  is the minute return of the reference market on day  $t$ . The firm individual  $\beta_i$  factor measures the sensitivity of  $R_{i,t}$  on the reference market. The abnormal return is calculated as follows:

$$AR_{i,t} = R_{i,t} - E(R_{i,t})$$

The cumulative abnormal return during period  $[t_1, t_2]$  is calculated by the following:

$$CAR_{i,t} [t_1, t_2] = \sum AR_{i,t}$$

As the formula above generates different values when  $t$  changes, this research uses endogenous windows of 15 and 60 minutes to offer concrete estimations. End of event window is set after no significant abnormal return is observed for 15 or 60 consecutive minutes with a 95% confidence level.

Notably, even though the market model is widely accepted as the standard model, there is also criticism towards its accuracy. The model assumes that the risk-free interest rate is constant, which conflicts with the reality that market returns vary. However, results from Table 1 to 4 confirm that the market model works well for this research. Therefore, this research will not expand to other models, such as the Market Adjusted or Garch model.

Lastly, to estimate each news's monetary impact, this research multiplies cumulative abnormal returns with the corresponding stock or market index's latest market capitalization.



#### IV. Data Analysis

To measure the impact of COVID-19 vaccine news, this research uses the intraday stock and index trade price data and related news data from Bloomberg. The following data are involved: the index price of S&P 500 (SPX), S&P Midcap 400 (MID), Russell 2000 (RTY), and the stock price of seven companies: Pfizer (PFE), Moderna (MRNA), Johnson & Johnson (JNJ), Novavax (NVAX), CureVac (CVAC), Gilead (GILD), and Regeneron (REGN). The first five are COVID-19 vaccine developers, and the rest are focusing on therapeutics of COVID-19. The rationale for this selection is that all of them are in phase three of the vaccine trial or leading in therapeutics, therefore more sensitive to research and development news. And S&P 500 is a commonly used index for the event study method (De Schrijver, 2013). Meanwhile, S&P 500 market index's price, S&P Midcap 400, Russell 2000 represents large-cap, mid-cap, and small-cap companies accordingly.

This research gathers Google search trend and stock price movement data to prove events are unexpected by the market, shown in Figure 1 to Figure 13. For Google search popularity trend, numbers represent search interest for the given region and time. A value of 100 is the peak popularity; 50 means that the term is half as popular; 0 means there was not enough data. Figure 1 to 4 show that Google search popularity for selected events is nearly unobservable before the announcement and hits the highest popularity level afterward. Thus, each event should be a shock to the market. From the stock price change shown in Figure 4 to Figure 13, we can also see sharp spikes at the selected announcement time. Under the assumption of event study, leakage of information will be instantly absorbed by the market and reflected on the stock price. Therefore, the observations above show selected events are unexpected. They also prove that the exact time of announcement used in this research is correct, as movements happened precisely at 9:30 am, the first effective trading minute for all events.

## V. Effects of News on Pharmaceutical and Biotech Companies

*Event 1: President Trump Used Regeneron's Unproved Cocktail Treatment (04:11 pm, October 2<sup>nd</sup>, 2020)<sup>7</sup>*

Figure 14 and Table 5 show the cumulative abnormal returns of seven selected firms around the first event. Most companies reacted positively towards the news, except for Novavax and Pfizer in the first 10 minutes and Moderna in the first two hours. For Regeneron, a significant cumulative abnormal return of 8% happened at 9:46 am, and then decreased to around 4% to 6%, which lasted for more than one trading day. Notably, Regeneron had previously disclosed positive results of remdesivir, but the stock price only surged until former President Trump's treatment.

Among all firms, Regeneron, CureVac, Novavax, Gilead and Moderna had the highest cumulative abnormal returns, all larger than 1%. However, because of Johnson & Johnson's large market capitalization, it had the most prominent capital gain of 3.1 billion, even more than Regeneron's 2.53 billion gain. Meanwhile, despite the competition between Gilead's remdesivir and Regeneron's REGN-COV2 antibody cocktail, Gilead also gained 1.82 billion in capitalization. Those results show that the vaccine race was not a zero-sum game, as the market confidence in Regeneron's COVID-19 antibody cocktail benefited almost all vaccine and therapeutics developers.

Results might also suggest that investors predicted there would be a greater demand than supply for COVID-19 related prevention and treatment methods for an extensive period, especially since President Trump's acceptance of treatment signals the severity of COVID-19 and can increase public trust towards COVID-19 healthcare.

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<sup>7</sup> This event happened after regular trading hours, so I pick 9:30 am, October 5<sup>th</sup>, 2020, the nearest regular trading time, as the effective announcement time.

*Event 2: Pfizer announced its vaccine to be 90% effective (06:45 am, November 9<sup>th</sup>, 2020)*<sup>8</sup>

Figures 7, 15 and Table 5 show that the Pfizer stock surged immediately after the announcement with large positive abnormal returns of about 12% within the first five minutes. It raised Pfizer's capitalization by a colossal amount of 17.32 billion. Other firms such as Moderna, Johnson & Johnson, and CureVac also reacted positively towards the news. Especially, Johnson & Johnson gained 9.76 billion. Overall, the positive reactions showed strong market confidence, especially since the 90% efficacy rate outperformed prior expectations.

Contrary to event 1, event 2 did not lead to gains for all. Novavax and Regeneron suffered significant losses, while Gilead had a moderate loss within the trading day but surged the day after. Novavax's drastic drop in stock price is likely due to its lag in development, small size, and questionable history in vaccine production, since it never delivered any vaccine to market for its 33-year history. Novavax was also overpriced - it was a popular bet on the vaccine race and had a more than 2000% price growth since March 2020. Consequently, it can be risky to keep investing in it.

For the two drugmakers, Regeneron and Gilead, the reason for their drop might be lower projected revenues. Since Pfizer is a reputable pharmaceutical company with strong government support and established supply and logistics chains, the Pfizer vaccine's distribution will likely decrease COVID-19 infections, thus decreasing the need for treatment in the mid-to-long term. In comparison, Gilead suffered less loss, which can imply that investors have higher expectations of Gilead's Veklury than Regeneron's cocktail treatment, although President Trump chose the latter over Gilead.

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<sup>8</sup> Both announcements happened before regular trading hours, so I pick 9:30 am, the opening of regular hours, as the announcement time for this research.

For Moderna, its positive returns can result from similar technology with Pfizer, as both are using a new approach of Messenger RNA (mRNA). Moderna is only 12% the size of Pfizer. Therefore, its capital gains from the Pfizer announcement suggest that small biotech companies are not less trusted than their big pharmaceutical counterparts, as investors still showed faith in the former despite the latter's advancement. Some might have seen the unique opportunity to invest in smaller biotech companies like Moderna, since they do have expertise in producing vaccines and yield a higher return once succeeding. Figure 9 and the following section demonstrate this strategy's success, as the disclosure of the Moderna vaccine's efficacy raised its stock from as low as 74 dollars per share (6 days before the announcement) to 100 dollars after the announcement.

***Event 3: Moderna announced vaccine efficacy of 94.5% and long shelf life at refrigerated temperatures (06:56 am, November 16<sup>th</sup>, 2020)***

Figure 9, 16 and Table 5, 6 show that Moderna attained colossal gains from its vaccine development, with a 9.47% cumulative abnormal return and a 3.23 billion market capitalization increase. This result is coherent since Moderna's vaccine is superior to Pfizer in many ways. It has a higher efficacy rate, a longer shelf life, and most importantly, a more attainable storage temperature. Pfizer's vaccine requires a minus 75 degrees Celsius condition, which cannot be met by many doctor's offices or pharmacies, and a short shelf life of seven days. Meanwhile, Moderna's vaccine merely requires a minus 20 degrees Celsius environment and can last for up to 30 days. Therefore, it is reasonable that Pfizer had a 10.18 billion drop in market capitalization and -4.75% cumulative abnormal returns.

Moderna's success also disrupted other companies, such as Johnson & Johnson, Novavax, and Regeneron. The first two were lagging in the process of development compared to Moderna

and Pfizer. Simultaneously, as both Moderna and Pfizer showed higher-than-expected efficacy rates, it raised the bar for upcoming vaccines. The rationales behind Regeneron's loss can be similar to that of event 2, which is lowered projected revenues. By comparing its stock market performance with Gilead, it shows that investors continued to favor Gilead than Regeneron.

Results on event 3 demonstrated investors' increasing trust in mRNA vaccines. Unlike most companies selected, the small German biotech company CureVac surged after Moderna's announcement. CureVac could potentially demonstrate a high efficacy rate and even longer shelf life than Moderna, adopting the same mRNA approach and supposedly more advanced technology for degradation preventions. It is also sponsored by the German government and can become the leading vaccine supplier for the European market. Therefore, it is reasonable that CureVac stock had 3.70% cumulative abnormal returns and a 0.49 billion market capitalization increase.

***Event 4:** Novavax vaccine demonstrated 89.3% efficacy, Johnson & Johnson announced 66% efficacy (4:05 pm, January 28<sup>th</sup>, 2021 & 08:03 am, January 29<sup>th</sup>, 2021)*

The two events happened at different time, but both influenced the market at 9:30 am, January 29<sup>th</sup>, 2021. Figure 17 and Table 5 and 6 show that Novavax was the primary beneficiary from the announcements, with 63.92% cumulative abnormal returns and 4.93 billion growth in market capitalization. Most other firms also reacted positively, except for Pfizer and Johnson & Johnson. The latter suffered -2.96% cumulative abnormal returns and a 14.20 billion loss in market capitalization, despite its research advancement. This contrast is plausible since Novavax has outperformed Johnson & Johnson in both efficacy and distribution.

The results revealed investors' collective opinions: Moderna and CureVac are the favorite players in the vaccine race; therapeutics such as Gilead and Regeneron still have growth potentials;

while Pfizer and Johnson & Johnson are likely to have limited revenues due to increased competitions from Moderna and Novavax. It also showed that Johnson & Johnson's unique advantage of a single shot does not compensate for its low efficacy in the market's viewpoint.

## **VI. Effects of News on the Market**

Table 7 shows that among all events selected, the approval of Pfizer's vaccine has the most profound positive effect on the market and firms of all sizes. S&P 500 increased by more than 3%, and its capitalization grew by 971 billion within one hour of the announcement. Small-cap and mid-cap firms also had high returns of about 5% and increased market capitalization between \$88.96 billion to 128.42 billion. As Pfizer's is the first approved American vaccine, the results show strong positive market sentiment and the high value of a COVID-19 vaccine.

Both event 1 and event 3 also yield positive returns for the market and all size sectors. The market gains after President Trump's physical acknowledgement of Regeneron's cocktail treatment demonstrate correlation between market optimism and increased credibility of the treatment drug candidate. And the market growth after Moderna's vaccine announcement highlights the value of an effective COVID-19 vaccine again. However, by comparing results of event 2 and event 3 on Table 3, it is notable that the market as a whole seems less excited over Moderna's vaccine than Pfizer's. It can be that investors have anticipated Moderna's research progress after Pfizer's announcement.

Event 4 is the only case where positive announcements generated overall negative market reactions, as the market dropped by 0.37% within an hour. A possible explanation is that the disappointment in Johnson & Johnson might have outweighed the positive sentiments towards Novavax. Table 7 together with Table 5 and 6 support the hypothesis that the private and public

benefits of COVID-19 vaccines and treatment drugs generally align, as only event 4 yielded negative market reactions.

Results of Table 7 also partly support the claim of Li and Yang (2017) that individual stock sentiment influences small-cap firms more than large-caps. Both Russell 2000 and S&P Midcap 400 had higher returns than S&P 500 during all four events. However, they are also generally less impacted during event 4, when the announcements caused overall negative effectives.

## **VII. Conclusions**

Results of the four events show that COVID-19 vaccines and treatment drugs can be highly lucrative for companies, as progress in development can lead to billions of growths in market capitalization and return rate as high as 63.92%. Meanwhile, the competition between developers is increasingly fierce. Initially any development progress will bring collective gains for the whole sector, but the market gradually developed preference for certain companies, such as Moderna and Gilead. Their progress is more likely to have a negative impact on others, while they are less likely to be negatively affected. However, the vaccine race is still not a zero-sum game, as some companies with similar technology and overlapping market can mutually benefit from each other's positive news, such as Moderna and CureVac. Results also show that the private and public benefits of COVID-19 vaccines and treatment drugs generally align, except for the case of event 4. Lastly, positive market sentiment seems to influence small-cap and mid-cap firms more than large-caps, while negative events have less impact on them.

## Bibliography

- Aktas, Elvan. "Intraday Stock Returns and Performance of a Simple Market Model." *Applied Financial Economics* 18, no. 18 (2008): 1475–80.  
<https://doi.org/10.1080/09603100701720294>.
- Alfaro, Laura, Anusha Chari, Andrew Greenland, and Peter Schott. "Aggregate and Firm-Level Stock Returns During Pandemics, in Real Time," (2020). <https://doi.org/10.3386/w26950>.
- Baker, Scott, Nicholas Bloom, Steven Davis, Kyle Kost, Marco Sammon, and Tasaneeya Viratyosin. "The Unprecedented Stock Market Impact of COVID-19," (2020).  
<https://doi.org/10.3386/w26945>.
- Brown, Gregory, Cliff, Michael. "Corrigendum to 'Investor sentiment and the near-term stock market'" [*Journal of Empirical Finance*. 11 (2004): 627-628.  
10.1016/j.jempfin.2004.04.001.
- Cox, Josue, Daniel Greenwald, and Sydney Ludvigson. "What Explains the COVID-19 Stock Market?," (2020). <https://doi.org/10.3386/w27784>.
- Diestre, Luis, and Nandini Rajagopalan. "Toward an Input-Based Perspective on Categorization: Investor Reactions to Chemical Accidents." *Academy of Management Journal* 57, no. 4 (2014): 1130–53. <https://doi.org/10.5465/amj.2011.1096>.
- Ding, Wenzhi, Ross Levine, Chen Lin, and Wensi Xie. "Corporate Immunity to the COVID-19 Pandemic," (2020). <https://doi.org/10.3386/w27055>.
- Hwang, Thomas J. "Stock Market Returns and Clinical Trial Results of Investigational Compounds: An Event Study Analysis of Large Biopharmaceutical Companies." *PLoS ONE* 8, no. 8 (2013). <https://doi.org/10.1371/journal.pone.0071966>.
- Li, Jinfang, Yang, Chunpeng "The cross-section and time-series effects of individual stock sentiment on stock prices", *Applied Economics*, 49:47, (2017): 4806-4815, DOI: 10.1080/00036846.2017.1293795
- Lakdawalla, Darius N. "Economics of the Pharmaceutical Industry." *Journal of Economic Literature* 56, no. 2 (2018): 397–449. <https://doi.org/10.1257/jel.20161327>.
- Marshall, Ben R., Nick Nguyen, and Nuttawat Visaltanachoti. "A Note on Intraday Event Studies." *European Accounting Review* 28, no. 3 (2018): 605–19.  
<https://doi.org/10.1080/09638180.2018.1530606>.
- Naubert, Christopher, and Linda L Tesar. "The Value of Systemic Unimportance: The Case of MetLife." *Review of Finance* 23, no. 6 (2018): 1069–78.  
<https://doi.org/10.1093/rof/rfy037>.



Pérez-Rodríguez, Jorge V., and Beatriz G. Valcarcel. “Do Product Innovation and News about the R&D Process Produce Large Price Changes and Overreaction? The Case of Pharmaceutical Stock Prices.” *Applied Economics* 44, no. 17 (2012): 2217–29. <https://doi.org/10.1080/00036846.2011.562172>.

Spitz, Janet, and Mark Wickham. “Pharmaceutical High Profits: The Value of R&D, or Oligopolistic Rents?” *American Journal of Economics and Sociology* 71, no. 1 (2012): 1–36. <https://doi.org/10.1111/j.1536-7150.2011.00820.x>.

Appendix

**Figure 1: Google Search Popularity (%) for "Trump Regeneron Cocktail" in the U.S**

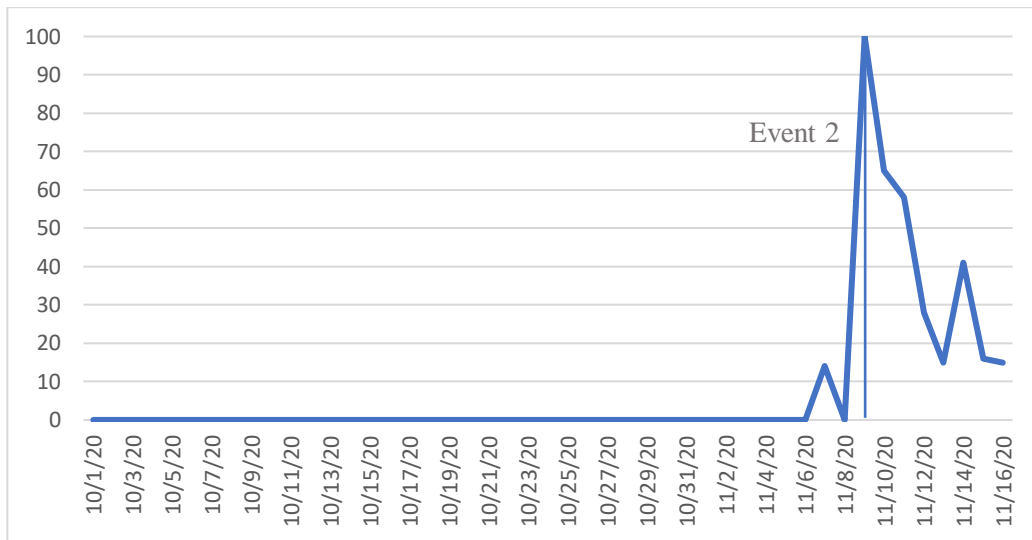
September 25, 2020 - October 7, 2020



Source: Google Trends.

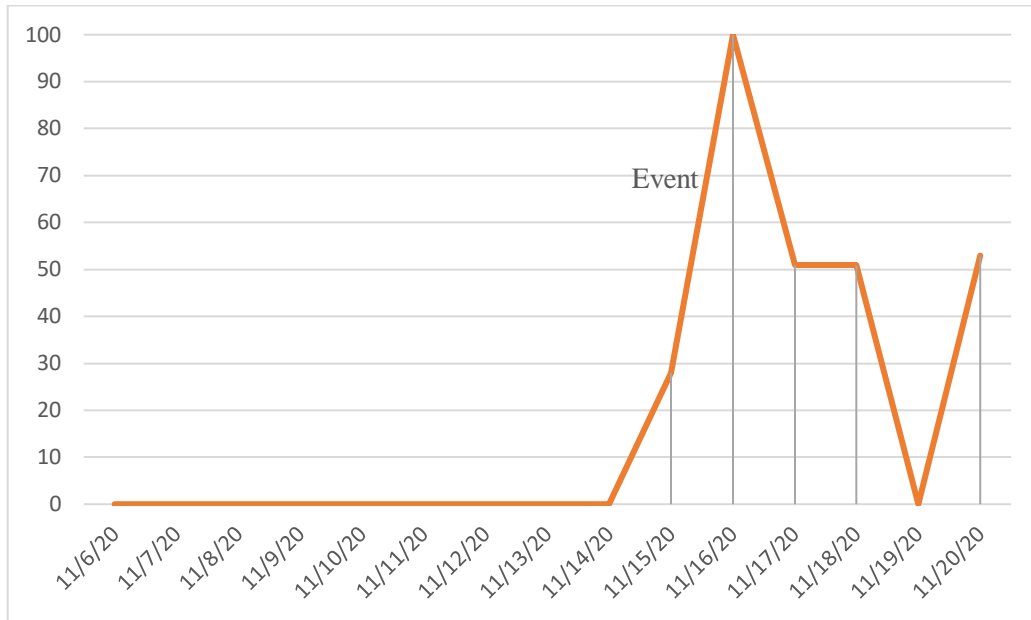
**Figure 2: Google Search Popularity (%) for "Pfizer Vaccine Effective " in United States**

October 15, 2020 - December 16, 2020



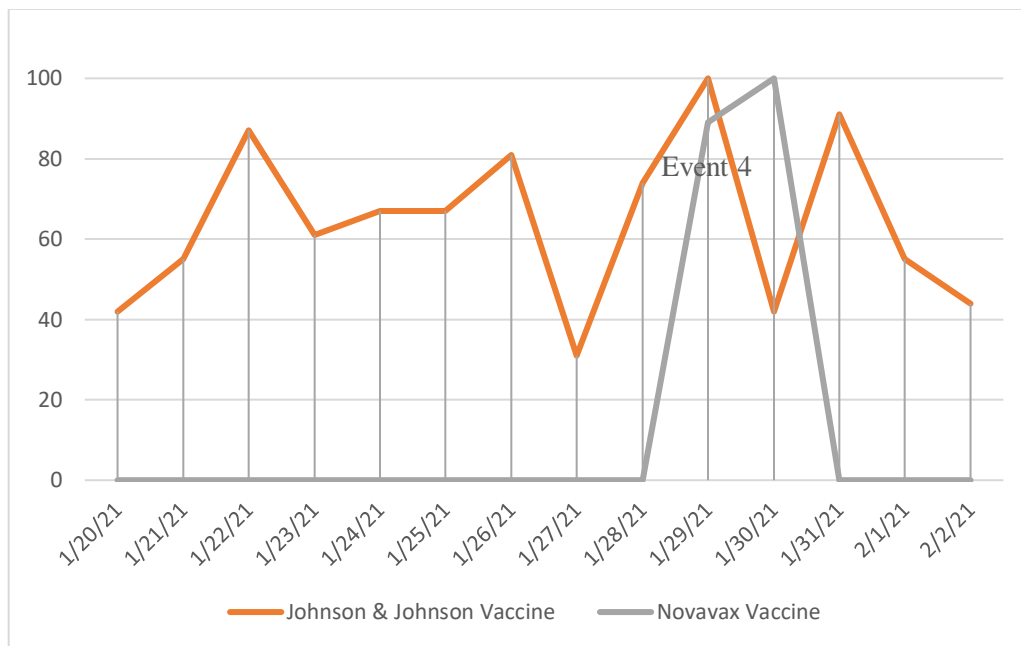
Source: Google Trends.

**Figure 3: Google Search Popularity (%) for "Moderna Vaccine Effective" in the U.S**  
November 16, 2020 - November 20, 2020



Source: Google

**Figure 4: Google Search Popularity (%) for "Johnson & Johnson vaccine" and "Novavax Vaccine" in the U.S**  
January 10, 2021 - February 2, 2021



Source: Google

**Figure 5: Regeneron Stock Price Around Event 1**  
September 16, 2020 - October 5, 2020



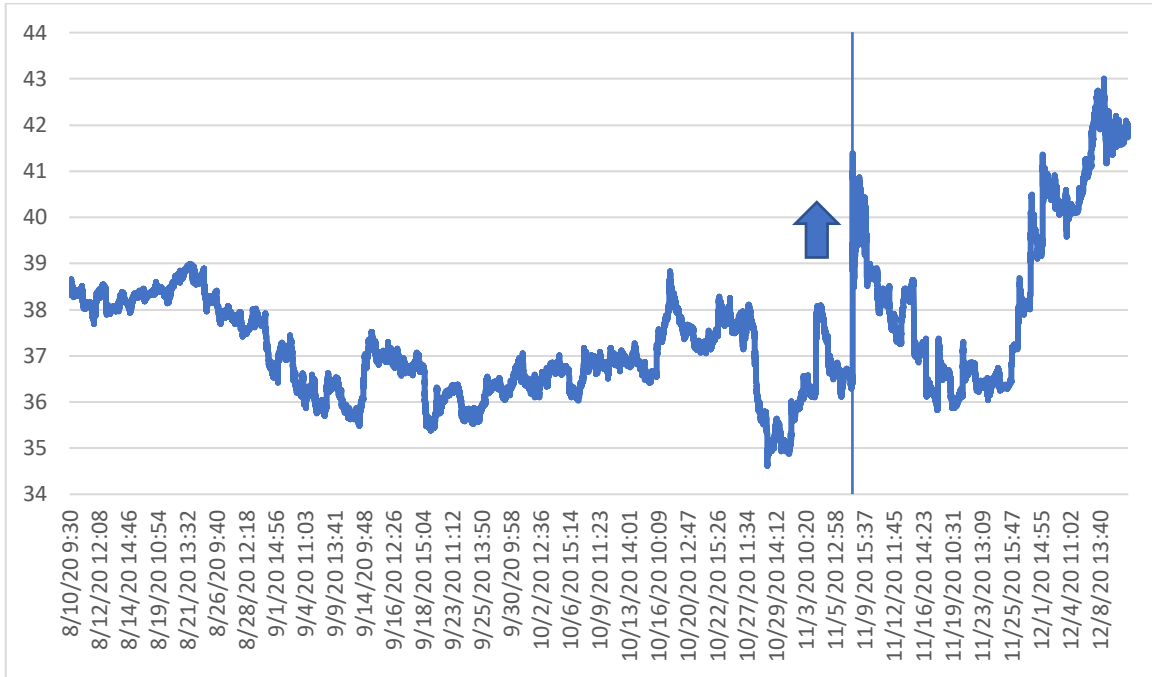
Source: Bloomberg.

**Figure 6: S&P500 Index Price Around Event 1**  
September 16, 2020 - October 5, 2020



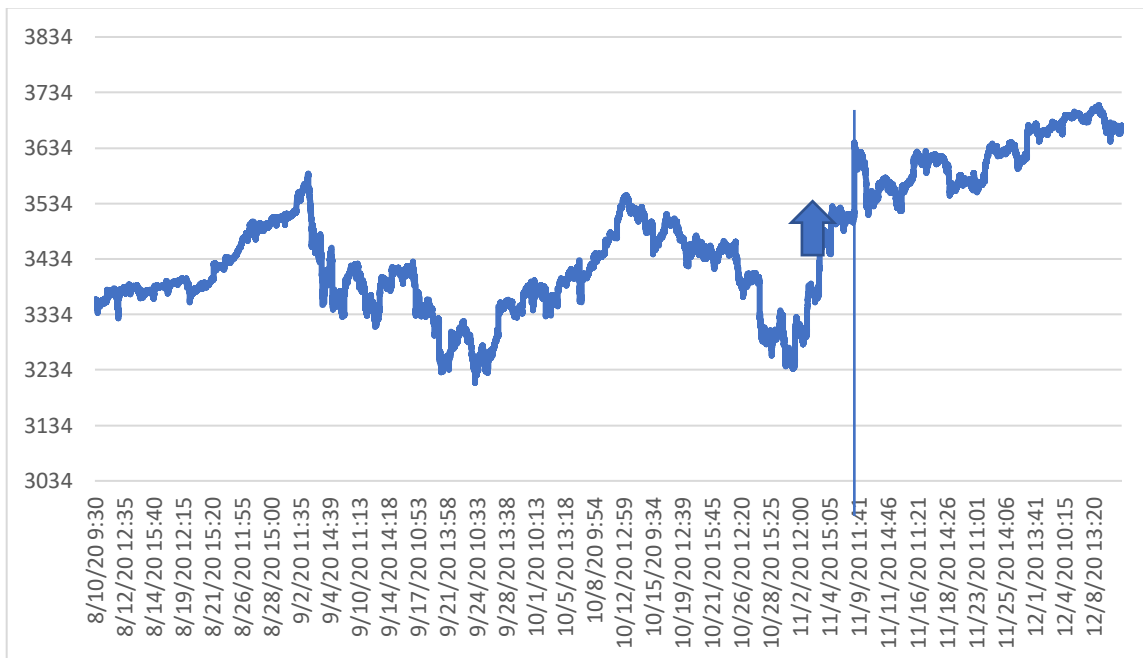
Source: Bloomberg.

**Figure 7: Pfizer Stock Price Around Event 2**  
August 10, 2020 - December 8, 2020



Source: Bloomberg.

**Figure 8: S&P 500 Index Price Around Event 2**  
August 10, 2020 - December 8, 2020



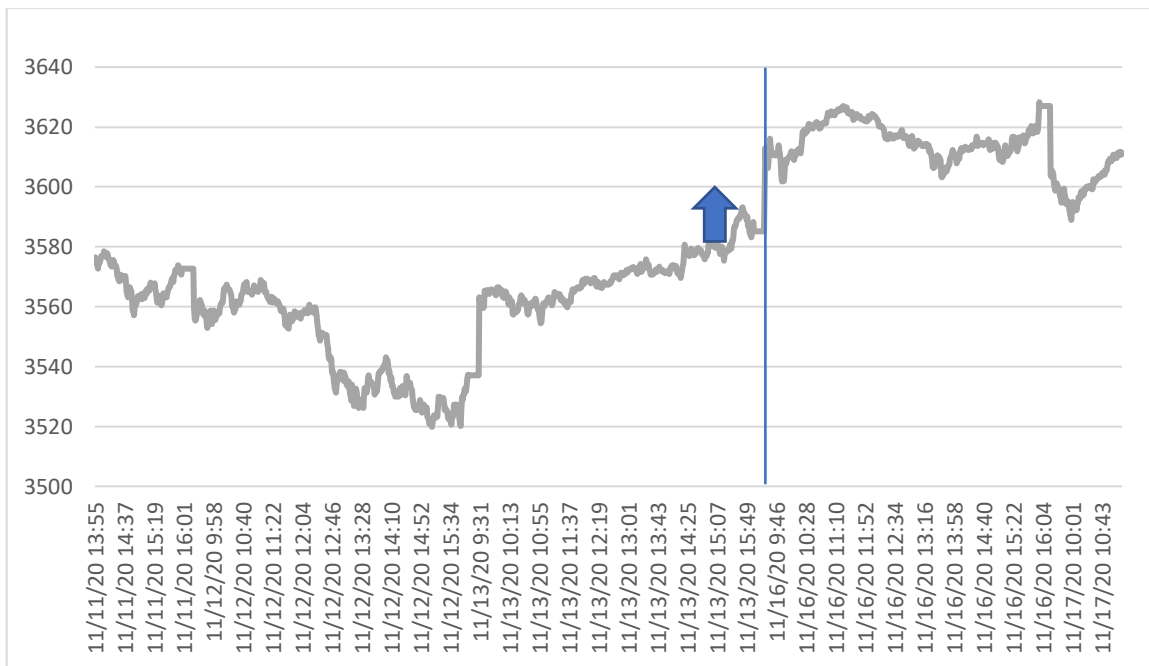
Source: Bloomberg.

**Figure 9: Moderna Stock Price Around Event 3**  
November 6, 2020 - November 19, 2020



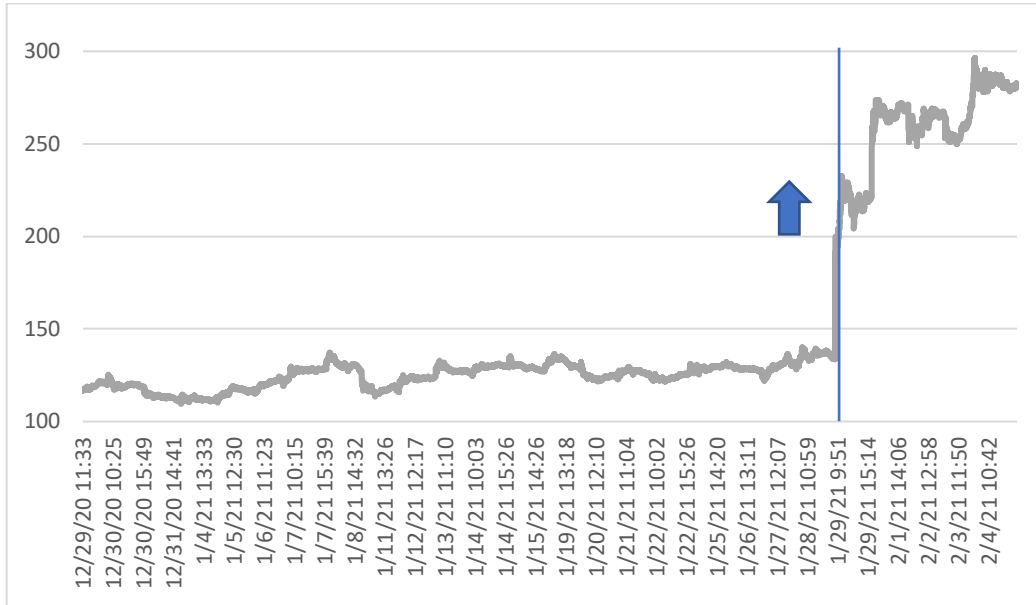
Source: Bloomberg.

**Figure 10: S&P 500 Index Price Around Event 3**  
November 6, 2020 - November 19, 2020



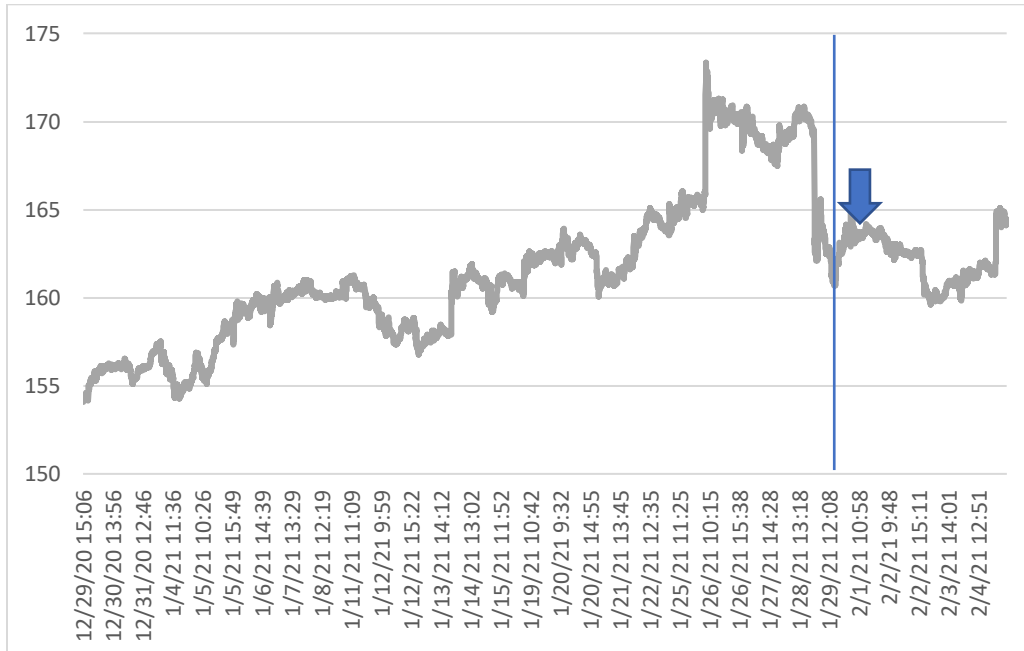
Source: Bloomberg.

**Figure 11: Novavax Stock Price Around Event 4**  
January 29, 2020 - February 4, 2021



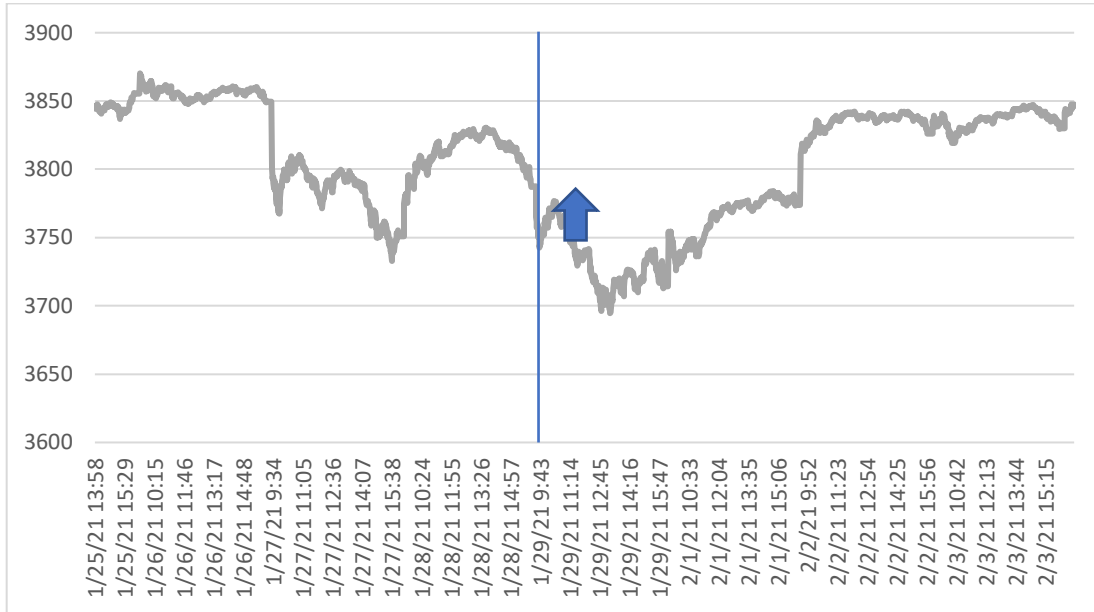
Source: Bloomberg.

**Figure 12: Johnson & Johnson Stock Price Around Event 4**  
January 29, 2020 - February 4, 2021



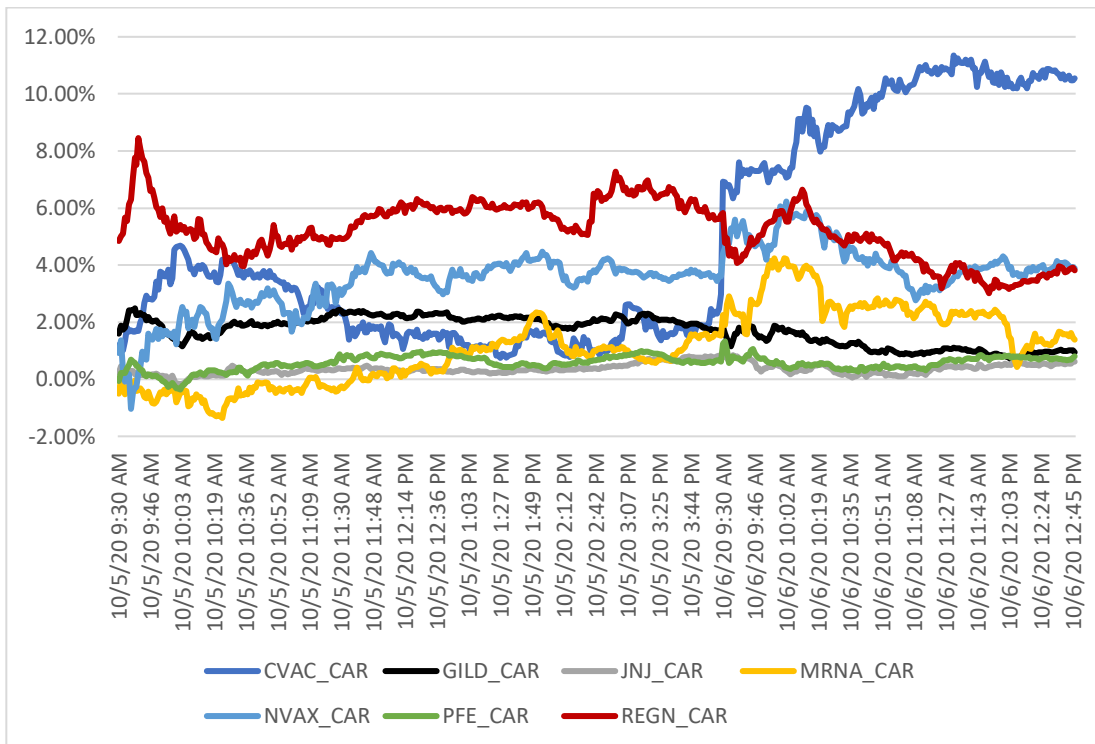
Source: Bloomberg.

**Figure 13: S&P 500 Index Price Around Event 4**  
January 25, 2021 - February 3, 2021



Source: Bloomberg.

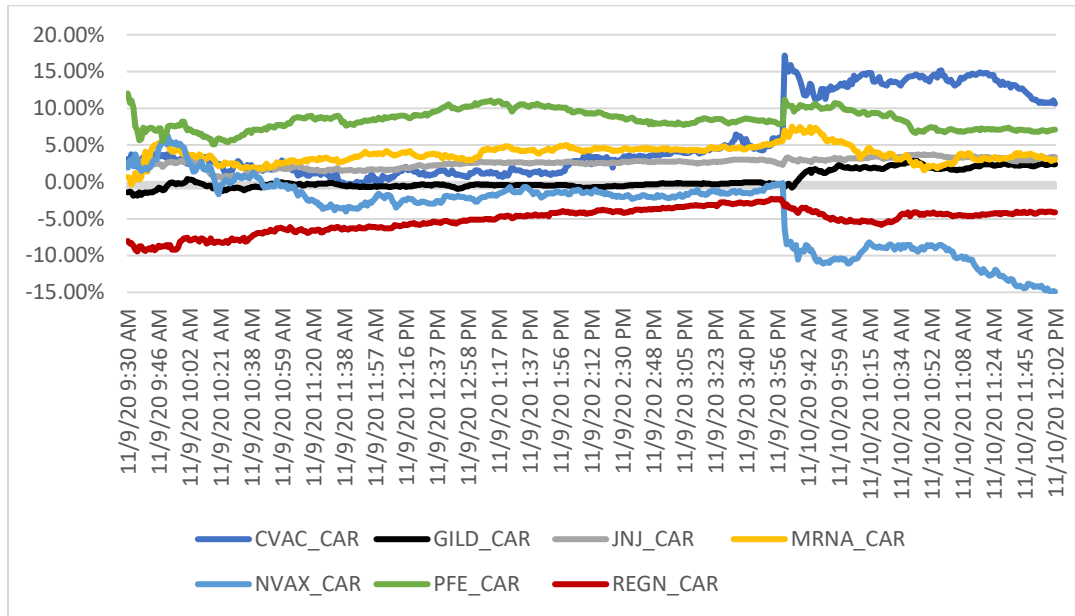
**Figure 14: CAR of Selected Companies After Event 1**  
October 5, 2020 - October 6, 2020



Source: Bloomberg & by calculation.

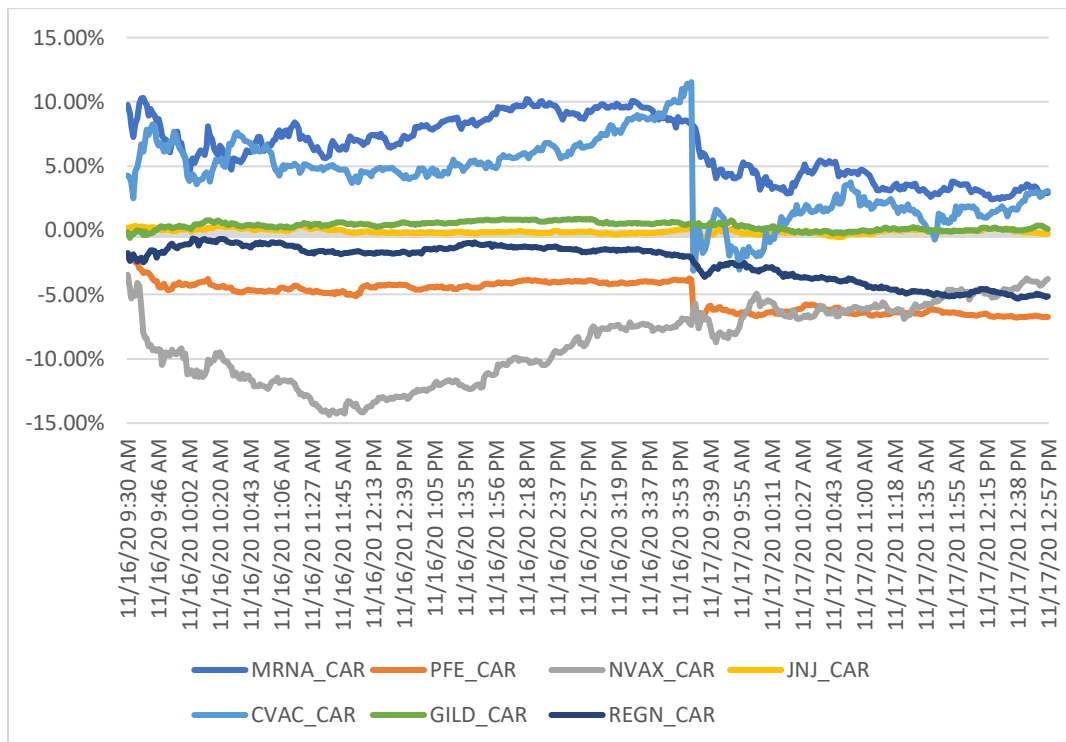


**Figure 15: CAR of Selected Companies After Event 2**  
November 9, 2020 - November 10, 2020



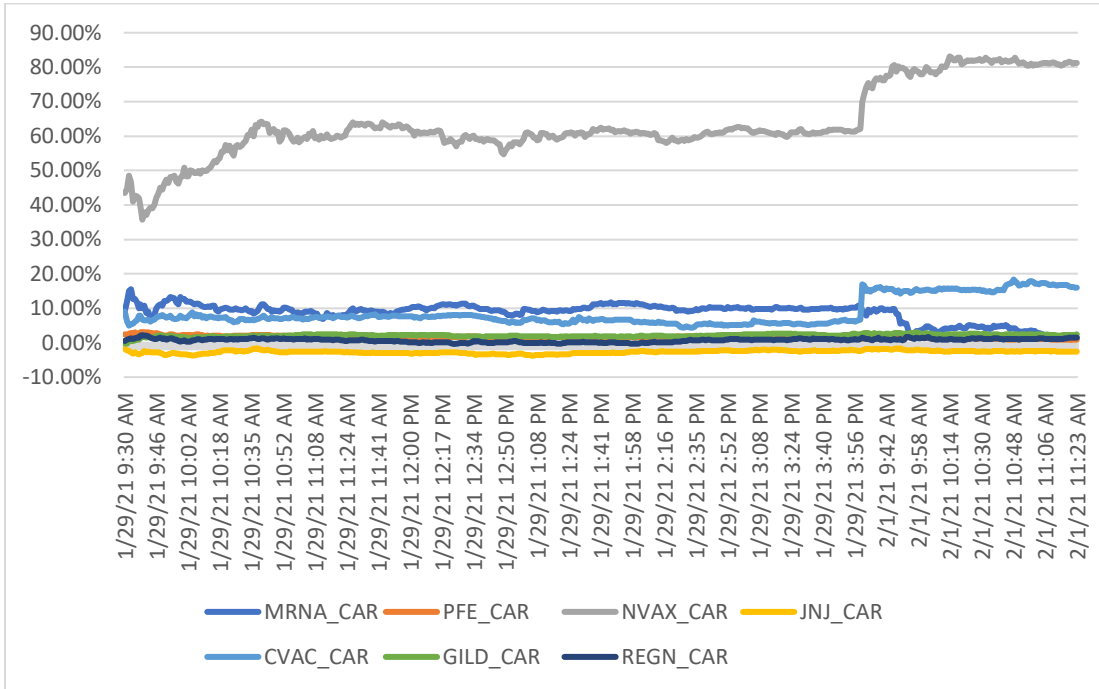
Source: Bloomberg & by calculation.

**Figure 16: CAR of Selected Companies After Event 3**  
November 16, 2020 - November 17, 2020



Source: Bloomberg & by calculation.

**Figure 17: CAR of Selected Companies After Event 3**  
 January 29, 2021 - February 1, 2021



Source: Bloomberg & by calculation.

**Table 1: Market Models for Selected Firms Estimated Before Event 1**

	<i>Dependent variables</i>						
	PFE	JNJ	MRNA	CVAC	NVAX	GILD	REGN
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SPX	0.349*** (0.010)	0.355*** (0.010)	1.585*** (0.010)	1.151*** (0.103)	1.829*** (0.010)	0.440*** (0.014)	0.915*** (0.016)
Constant	-0.00001 (0.00001)	-0.00000 (0.00001)	0.00000 (0.00002)	0.00004 (0.00001)	-0.00002 (0.00004)	-0.00001 (0.00001)	-0.00001 (0.00001)
Obs.	8,029	8,029	8,029	8,029	8,029	8,029	8,029
R <sup>2</sup>	0.124	0.142	0.218	0.015	0.096	0.112	0.281
Adjusted R <sup>2</sup>	0.123	0.142	0.218	0.015	0.096	0.112	0.281
R. S. E.	0.001	0.001	0.002	0.007	0.004	0.001	0.001
F Statistic	1,131.827***	1,333.425***	2,240.060***	124.038***	848.956***	1,015.983***	3,141.848***

Note: R. S. E. is residual standard error  
\*\*\*p<0.01

**Table 2: Market Models for Selected Firms Estimated Before Event 2**

	<i>Dependent variables</i>						
	PFE	JNJ	MRNA	CVAC	NVAX	GILD	REGN
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SPX	0.500*** (0.008)	0.504*** (0.007)	1.352*** (0.023)	1.068*** (0.058)	1.668*** (0.038)	0.530*** (0.010)	0.867*** (0.014)
Constant	-0.00000 (0.00001)	-0.00000 (0.00001)	0.00000 (0.00002)	0.00002 (0.00004)	-0.00003 (0.00003)	-0.00001 (0.00001)	-0.00001 (0.00001)
Obs.	15,684	15,684	15,684	15,684	15,684	15,684	15,684
R <sup>2</sup>	0.194	0.239	0.182	0.021	0.111	0.157	0.204
Adjusted R <sup>2</sup>	0.194	0.239	0.182	0.021	0.111	0.157	0.204
R. S. E.	0.001	0.001	0.002	0.005	0.003	0.001	0.001
F Statistic	3,780.563***	4,914.783***	3,481.897***	336.186***	1,956.309***	2,927.371***	4,008.621***

Note: R. S. E. is residual standard error  
\*\*\*p<0.01

**Table 3: Market Models for Selected Firms Estimated Before Event 3**

	<i>Dependent variables</i>						
	PFE	JNJ	MRNA	CVAC	NVAX	GILD	REGN
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SPX	0.442*** (0.009)	0.446*** (0.008)	1.390*** (0.024)	1.017*** (0.064)	1.669*** (0.041)	0.513*** (0.010)	0.891*** (0.015)
Constant	-0.00000 (0.00001)	-0.00000 (0.00001)	0.00000 (0.00002)	0.00002 (0.00004)	-0.00003 (0.00003)	-0.00001 (0.00001)	-0.00000 (0.00001)
Obs.	14,636	14,636	14,636	14,636	14,636	14,636	14,636
R <sup>2</sup>	0.155	0.190	0.184	0.017	0.105	0.144	0.201
Adjusted R <sup>2</sup>	0.155	0.190	0.184	0.017	0.104	0.144	0.201
R. S. E.	0.001	0.001	0.002	0.005	0.003	0.001	0.001
F Statistic	2,676.227***	3,430.616***	3,295.135***	255.084***	1,707.849***	2,465.206***	3,675.463***

Note: R. S. E. is residual standard error  
\*\*\*p<0.01

**Table 4: Market Models for Selected Firms Estimated Before Event 4**

	<i>Dependent variables</i>						
	PFE	JNJ	MRNA	CVAC	NVAX	GILD	REGN
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SPX	0.861*** (0.010)	0.606*** (0.006)	1.348*** (0.026)	1.129*** (0.044)	1.675*** (0.030)	0.479*** (0.007)	0.632*** (0.011)
Constant	-0.00000 (0.00001)	0.00000 (0.00000)	0.00002 (0.00002)	0.00004 (0.00003)	-0.00000 (0.00002)	-0.00000 (0.00000)	-0.00001 (0.00001)
Obs.	29,503	29,503	29,503	29,503	29,503	29,503	29,503
R <sup>2</sup>	0.198	0.287	0.086	0.022	0.097	0.134	0.095
Adjusted R <sup>2</sup>	0.198	0.287	0.086	0.022	0.097	0.134	0.095
R. S. E.	0.001	0.001	0.003	0.005	0.003	0.001	0.001
F Statistic	7,285.808***	11,891.310***	2,760.949***	659.687***	3,179.148***	4,679.189***	3,111.062***

Note: R. S. E. is residual standard error  
\*\*\*p<0.01

**Table 5: Cumulative Abnormal Returns by Event<sup>9</sup>**

		<b>PFE</b>	<b>MRNA</b>	<b>JNJ</b>	<b>NVAX</b>	<b>CVAC</b>	<b>GILD</b>	<b>REGN</b>
Event 1	Endogenous Window 15 minutes <sup>10</sup>	-0.05%	2.23%	0.16%	2.97%	2.88%	1.44%	5.10%
	Endogenous Window 60 minutes <sup>11</sup>	0.53%	1.76%	0.80%	2.76%	1.39%	2.33%	4.17%
Event 2	Endogenous Window 15 minutes	5.11%	4.70%	1.00%	-3.71%	2.84%	-0.05%	-6.32%
	Endogenous Window 60 minutes	8.57%	2.34%	2.61%	-13.49%	5.71%	-0.25%	-4.61%
Event 3	Endogenous Window 15 minutes	-4.39%	6.06%	-0.23%	-9.38%	4.23%	-0.19%	-1.35%
	Endogenous Window 60 minutes	-4.75%	9.47%	-1.12%	-11.13%	3.70%	0.59%	-3.03%
Event 4	Endogenous Window 15 minutes	2.28%	10.68%	-2.73%	48.42%	7.11%	1.76%	0.82%
	Endogenous Window 60 minutes	-4.09% <sup>12</sup>	0.33%	-2.96%	63.92%	13.85%	1.44%	1.14%

<sup>9</sup> Event 1: Trump Used Regeneron's Unproved Cocktail Treatment (4:11 pm, October 2nd, 2020).

Event 2: Pfizer announced its vaccine to be 90% effective (06:45 am, November 9th, 2020)

Event 3: Moderna announced vaccine efficacy of 94.5% (06:56 am, November 16th, 2020)

Event 4: Novavax vaccine demonstrated 89.3% efficacy, Johnson & Johnson announced 66% efficacy (4:05 pm, January 28th, 2021 & 08:03 am, January 29th, 2021)

<sup>10</sup> End of event window is set after no significant abnormal return is observed for 15 consecutive minutes with a 95% confidence level.

<sup>11</sup> End of event window is set after no significant abnormal return is observed for 60 consecutive minutes a 95% confidence level.

<sup>12</sup> Observed 58.6 hours after start of event 4.

**Table 6: Change of Company Market Capitalization by Event (Billions USD)<sup>13</sup>**

		PFE	MRNA	JNJ	NVAX	CVAC	GILD	REGN
Event 1	Endogenous Window 15 minutes	-0.10	0.58	0.61	0.18	0.24	1.12	3.10
	Endogenous Window 60 minutes	1.08	0.46	3.10	0.16	0.12	1.82	2.53
Event 2	Endogenous Window 15 minutes	10.32	1.30	3.76	-0.19	0.25	-0.04	-3.93
	Endogenous Window 60 minutes	17.32	0.65	9.76	-0.70	0.51	-0.19	-2.87
Event 3	Endogenous Window 15 minutes	-9.42	2.06	-0.91	-0.52	0.57	-0.15	-0.82
	Endogenous Window 60 minutes	-10.18	3.23	-4.40	-0.62	0.49	0.45	-1.85
Event 4	Endogenous Window 15 minutes	4.54	7.05	-12.15	3.73	1.15	1.43	0.45
	Endogenous Window 60 minutes	-8.16 <sup>14</sup>	0.22	-13.20	4.93	2.24	1.17	0.62

<sup>13</sup> Event 1: Trump Used Regeneron's Unproved Cocktail Treatment (4:11 pm, October 2nd, 2020).

Event 2: Pfizer announced its vaccine to be 90% effective (06:45 am, November 9th, 2020)

Event 3: Moderna announced vaccine efficacy of 94.5% (06:56 am, November 16th, 2020)

Event 4: Novavax vaccine demonstrated 89.3% efficacy, Johnson & Johnson announced 66% efficacy (4:05 pm, January 28th, 2021 & 08:03 am, January 29th, 2021)

<sup>14</sup> Observed 58.6 hours after start of event 4.

**Table 7: Market Return and Capitalization Change (Billions USD) by Event<sup>15</sup>**

		<b>RTY Return</b>	<b>RTY Capitalization Change</b>	<b>MID Return</b>	<b>MID Capitalization Change</b>	<b>SPX Return</b>	<b>SPX Capitalization Change</b>
Event 1	15 minutes	1.78%	39.94	1.46%	25.93	0.93%	268.21
	60 minutes	1.79%	40.18	1.45%	25.81	1.14%	329.51
	End of Trading Day	2.75%	61.80	2.28%	40.46	1.78%	516.52
Event 2	15 minutes	5.45%	130.76	6.36%	120.48	3.27%	993.06
	60 minutes	5.35%	128.42	4.70%	88.96	3.20%	971.35
	End of Trading Day	3.80%	91.06	2.82%	53.41	1.23%	375.05
Event 3	15 minutes	1.58%	40.20	1.20%	23.75	0.71%	219.66
	60 minutes	1.81%	45.94	1.49%	29.49	0.96%	296.25
	End of Trading Day	2.35%	59.84	2.00%	39.57	1.20%	372.13
Event 4	15 minutes	-0.09%	-2.97	-0.80%	-17.61	-1.05%	-350.97
	60 minutes	0.69%	21.57	-0.10%	-2.27	-0.37%	-122.92
	End of Trading Day	-1.59%	-50.18	-2.01%	-44.53	-1.98%	-660.85

<sup>15</sup> Event 1: Trump Used Regeneron's Unproved Cocktail Treatment (4:11 pm, October 2nd, 2020).

Event 2: Pfizer announced its vaccine to be 90% effective (06:45 am, November 9th, 2020)

Event 3: Moderna announced vaccine efficacy of 94.5% (06:56 am, November 16th, 2020)

Event 4: Novavax vaccine demonstrated 89.3% efficacy, Johnson & Johnson announced 66% efficacy (4:05 pm, January 28th, 2021 & 08:03 am, January 29th, 2021)

**Table 8: Event<sup>16</sup> Impact by Group: Announcing Company(s), Other Selected Companies, and the Market<sup>17</sup>**

		Announcing Company(s)		Other Selected Companies in Average		The Market (SPX)	
		Return	Capitalization Change	Return	Capitalization Change	Return	Capitalization Change
Event 1	15 minutes	5.10%	3.10	1.61%	0.44	0.93%	268.21
<b>REGN</b>	60 minutes	4.17%	2.53	1.60%	1.12	1.14%	329.51
Event 2	15 minutes	5.11%	10.32	-0.26%	0.19	3.27%	993.06
<b>PFE</b>	60 minutes	8.57%	17.32	-1.28%	1.19	3.20%	971.35
Event 3	15 minutes	6.06%	2.06	-1.89%	-1.88	0.71%	219.66
<b>MRNA</b>	60 minutes	9.47%	3.23	-2.63%	2.69	0.96%	296.25
Event 4	15 minutes	45.69% <sup>18</sup>	-8.42 <sup>19</sup>	4.53%	2.92	-1.05%	-350.97
<b>NVAX, JNJ</b>	60 minutes	60.96%	-8.27	2.53%	0.85	-0.37%	-122.92

<sup>16</sup> Event 1: Trump Used Regeneron's Unproved Cocktail Treatment (4:11 pm, October 2nd, 2020).

Event 2: Pfizer announced its vaccine to be 90% effective (06:45 am, November 9th, 2020)

Event 3: Moderna announced vaccine efficacy of 94.5% (06:56 am, November 16th, 2020)

Event 4: Novavax vaccine demonstrated 89.3% efficacy, Johnson & Johnson announced 66% efficacy (4:05 pm, January 28th, 2021 & 08:03 am, January 29th, 2021)

<sup>17</sup> Announcing companies are noted in the first column; capitalizations measured in billions USD.

<sup>18</sup> Calculated by summing return of NVAX and JNJ. NVAX outweighed JNJ.

<sup>19</sup> Calculated by summing capitalization changes of NVAX and JNJ. JNJ outweighed NVAX